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LONGLEAF PINE (*PINUS PALUSTRIS* MILL.) GROWTH IN BOGS

M.H. MacRoberts & B.R. MacRoberts

Bog Research, 740 Columbia, Shreveport, Louisiana 71104 U.S.A.

&

Herbarium, Museum of Life Sciences, Louisiana State University in Shreveport, Shreveport, Louisiana 71115 U.S.A.

ABSTRACT

We measured growth rates and mortality of longleaf pine planted in a clear-cut bog and in an adjacent clear-cut mesic site. Longleaf pine grew more slowly and had a higher mortality in the bog than in the drier site. Longleaf appears to be poorly adapted to saturated soils.

KEY WORDS: Longleaf pine, *Pinus palustris*, tree growth, Kisatchie National Forest, bog, soil moisture

INTRODUCTION

In the West Gulf Coastal Plain, bogs are open communities (Nixon & Ward 1986; Bridges & Orzell 1989; MacRoberts & MacRoberts 1993; Harcombe, *et al.* 1993). They have a diverse herbaceous layer and, if frequently burned, are almost devoid of woody vegetation. Often a few scattered and stunted longleaf pine (*Pinus palustris* Mill.), an associated species of bog habitats in the West Gulf Coastal Plain, occur in them. In two previous papers we considered the problem of what keeps bogs open and why a few longleaf pines survive and grow to maturity in them (MacRoberts & MacRoberts 1990, 1993; see also Streng & Harcombe 1982).

While examining a bog on the Winn District of the Kisatchie National Forest, Natchitoches Parish, Louisiana, that had been clear-cut and replanted with longleaf pine, we noted that longleaf in the bog were growing much more slowly than in adjacent drier areas. This offered the opportunity to document some aspects of bog dynamics. We gathered quantitative data on the growth and survival of longleaf pine in the bog and in adjacent drier areas to further explore the factors involved in keeping bogs open.

METHODS

The bog is located in T13N R6W Sec. 26 and measures about 1.0 ha. It and the surrounding 20 ha. were clear-cut in 1990. The entire site was prepared by drum chopping followed by a prescribed burn and was machine replanted with bare-root longleaf pine seedlings in early 1991. The replanting was evenly distributed (1.8 m × 2.4 m), at a density of 2200 seedlings per ha. Since initial planting, the site has been burned twice. The first burn occurred in the winter (January/February) of 1992 and the second in the early spring (April) of 1994. The bog is located in the middle of the eastern section of the clear-cut. It is on a slight slope of about 3-5° and is seepage fed: while not inundated, the soil is permanently saturated. Common species in the bog include *Aletris aurea* Walt., *Burmannia capitata* (Walt.) Mart., *Drosera capillaris* Poir., *Eriocaulon decangulare* L., *Lachnocaulon anceps* (Walt.) Morong., *Lycopodium* spp., *Marshallia graminifolia* (Walt.) Small subsp. *tenuifolia* (Raf.) L. Watson, *Pinguicula pumila* Michx., *Polygala cruciata* L., *Pogonia ophioglossoides* (L.) Juss., *Rhexia petiolata* Walt., *Rhynchospora* spp., *Sabatia gentianoides* Ell., *Utricularia subulata* L., *Xyris baldwiniana* Schultes, and *Viola primulifolia* L. For further information on nearby bogs and the area in general see MacRoberts & MacRoberts (1988) and Martin & Smith (1991).

The site is not seeding in. All pines in the study area were planted and there are no seed trees within hundreds of meters.

In November 1995 we established five permanent circular plots. Plot 1, measuring 0.0728 ha., was established in the center of the bog. Four plots (Plots 2-5) each one quarter the size of Plot 1 were established in the drier (non-bog) area surrounding the bog at each cardinal point relative to Plot 1. Since the bog slopes westward, the eastern plot (Plot 2) was upslope, the western plot (Plot 4) was downslope, and two plots were at the same elevation as Plot 1 north and south (Plots 3 and 5, respectively). Each non-bog plot was located 25 to 50 meters outside the bog.

The height of all longleaf pines, the only trees present, was measured in all plots in November 1995 and 1996. Height to the nearest dm was measured from ground to tip of the terminal bud. Grass stage seedlings (without stem) were counted in the 1 dm class.

We examined all pines within the plots for evidence of stress and disease. This included signs of brown spot, stunted (short) or chlorotic needles, and small or absent growth bud.

For additional data on stress and disease, we examined fifty randomly selected grass stage individuals in the bog and recorded whether they showed any of these characteristics.

Finally, we made a visual examination of the growing conditions of 21 of the tallest pines in the bog to see if they were growing in wetter or drier areas, or in areas that were either higher or lower than the surrounding substrate.

Four soil samples from the upper 15 cm were taken from within the bog plot, and one each from the surrounding Plots 2-5 to see if there were any differences in soil chemistry between bog and non-bog plots. Samples were analyzed by A. & L. Agricultural Laboratories, Memphis, Tennessee.

RESULTS

On November 28, 1995 the bog plot had 55 longleaf pines; the four non-bog plots had a combined total of 89 longleaf pines. Plots 2-5 had a higher density of longleaf than Plot 1: Plot 2 = 20, Plot 3 = 20, Plot 4 = 22, Plot 5 =27. The original planting density was 160 seedlings per 0.0728 ha. Thus, survival in the bog plot was 34% and in the non-bog plots, 56%.

On November 13, 1996 we resurveyed the plots. Plot 1 had 49 longleaf pines; Plots 2-5 had a combined total of 86 longleaf pines. The number of trees in the non-bog plots was: Plot 2 = 19, Plot 3 = 18, Plot 4 = 22, and Plot 5 = 27. By 1996, survival rate had changed to 31% in the bog plot and 54% in non-bog plots.

Between 1995 and 1996 there was a loss of six trees in the bog plot (11% of the total) and a loss of only three trees in the non-bog plots (3% of the total).

Table 1 summarizes size data for longleaf pines in 1995 and 1996.

Table 1. Longleaf pine heights (in percentage) inside and outside bog.

Height class in dm	In Bog		Outside Bog	
	1995	1996	1995	1996
1-5	85	62	25	12
6-10	9	18	30	12
11-15	6	10	38	17
16-20		4	5	22
21-25		6	2	28
26-30				7
31-35				1
36-40				1

In 1995, the mean height for the bog plot longleaf pines was 2.9 dm (SD = 3.1 dm) and that for non-bog plot longleaf was 9.3 dm (SD = 5.1 dm). In 1996, these figures were 5.9 dm (SD = 5.8 dm) and 16.7 dm (SD = 7.9 dm), respectively. In other words, the trees in the bog were one-third the height of those in the mesic areas. We used the SAS NPAR1WAY procedure to compare the differences between bog and non-bog populations in each year's samples (SAS /STAT 1987). Calculations of linear rank statistics are based on Wilcoxon, Median, Van der Waerden, and Savage. In addition, NPAR1WAY calculates two statistics -- Kolmogorov-Smirnov and Cramer-von Mises -- based on the empirical distribution of the sample. In all the statistics, P = .0001 level.

Our observations on stress showed that 28 (51%) of the longleaf in Plot 1 were stressed or diseased; whereas only three (3%) of the trees in Plots 2-5 showed signs of stress and disease. It is interesting that two of the affected individuals outside the bog were grass stage.

Of the 50 grass stage longleaf examined in the bog as a whole for stress or disease, 45 (90%) showed one or more signs of disease and /or stress: 21 had brown spot disease, 40 had chlorotic needles, 39 had stunted needles, and 40 showed little or no bud development.

Twenty of the 21 tallest trees in the bog grew on higher and drier ground than the surrounding landscape, a microgeographical difference measurable in centimeters, caused by previous timbering and replanting that left the ground slightly furrowed and hummocked.

Soil data are presented in Table 2. There appeared to be no difference in soil chemistry among the plots (Wald-Wolfowitz runs test).

DISCUSSION

What explains the difference in number and height of longleaf pines between the bog plot and the four non-bog plots?

Shading can be excluded since the longleaf pines in the study area were sufficiently spaced so that all received equal solar radiation. Soil differences also seem to be unimportant since soils in all plots belong to the same morphological type (Martin, *et al.* 1990) and had the same general chemical composition (although possible trace element differences in soil chemistry can never be totally ruled out). However, since it is generally agreed that longleaf pine grows well on relatively poor soils (Wahlenberg 1946), it would appear that soil chemistry is probably not the important factor in explaining the difference in tree growth.

This leaves several interrelated factors: stress, fire, and disease. While growth rates of longleaf pine apparently have not been experimentally studied along a continuous moisture gradient (Fowells 1975; Wahlenberg 1946; Bruser pers. comm.),

Table 2. Soil characteristics of bog and non-bog plots.

		Exchangeable Ions (ppm)				
Sample	pH	P	K	Ca	Mg	OM%
Plot 1						
Sample 1	4.8	2	27	120	30	4.2
Sample 2	4.6	1	21	80	21	4.7
Sample 3	4.9	2	23	60	16	1.6
Sample 4	4.9	2	21	100	27	2.3
Mean plot 1	4.8	1.8	23	90	23.5	3.2
Plot 2	5.2	2	28	180	28	2.5
Plot 3	5.0	2	25	210	36	3.9
Plot 4	4.9	3	26	80	20	1.3
Plot 5	5.0	3	29	60	15	0.9
Mean plots 2-5	5.0	2.5	27	132.5	24.8	2.2

site condition reports generally recognize that longleaf pine, while showing a wide range of habitat tolerance (Wells & Shunk 1931), does not grow well in continuously saturated soils but prefers better-drained and drier areas (Wahlenberg 1946; Shoulders 1983; see also Ware, Frost, & Doerr 1993). This generalization finds support in our earlier study of pine growth in bogs. In that study, we found that average tree ring width of longleaf pines in bogs was one-third that of longleaf in drier upland areas (MacRoberts & MacRoberts 1993). Our observation that the tallest trees in the bog occurred on slight rises also supports this idea.

Brown spot disease is associated with strong light (stimulating stomata opening) and high humidity, conditions that occur in bogs that often have standing water (Kais 1975). Because brown spot defoliates, it is a starvation disease resulting in decreased growth that generally persists in successive growing seasons and makes the tree more vulnerable to successive reinfestations (Wahlenberg 1946). If seedlings do not die as a direct result of unfavorable hydric conditions, debilitation increases vulnerability to disease. The prevalence of brown spot among grass stage individuals in Plot 1 supports this idea.

Fire also affects seedling growth and survival. Studies of grass and pre-grass stage longleaf pines have shown significant size effects on survival from fire, particularly fire intensity (temperature), which in turn is directly related to fuel load (Wahlenberg 1946; Grace & Platt 1995a, 1995b). Brown spot disease and the generally stressed condition of the plant increase foliage flammability and expose the growth bud, again reducing seedling survival. Also the tree remains in a vulnerable condition for a longer time.

The few longleaf pines that do survive in bogs (MacRoberts & MacRoberts 1993) probable do so because, while the species is adapted to a wide range of habitat conditions (Wells & Shunk 1931; Wahlenberg 1946; Platt, *et al.* 1988), it is one of the few woody species adapted to fire and can therefore survive however stressful the growing conditions may be (Streng, *et al.* 1993). Slight elevational differences within a bog may provide just enough difference in moisture to allow longleaf pine to survive. In the absence of fire, other woody species invade bogs.

While we have discussed several possible factors involved in keeping bogs open, in the present case fire is probably not a major factor. This bog has not been burned since 1994, and yet it is losing longleaf pines faster than the surrounding drier areas and the trees in the bog are growing much more slowly. Even without fire, there would be large differences between the density, and certainly in the size, of pines in bogs and in drier areas. With fire, we suspect that the difference would be intensified. Many of the longleaf pines in the bog are sickly and would undoubtedly be destroyed by fire.

Our observations suggest, then, that a combination of interrelated factors may keep bogs open: stress due to soil saturation, disease, and fire. Soil saturation retards growth causing increased mortality, but also increases vulnerability to fire and disease by prolonging the grass stage of development.

But our primary purpose here has not been to discover the underlying reasons why longleaf pines have different growth and survival rates in bogs and in drier areas, but rather to document that there is a difference, which aids in explaining why bogs are open communities.

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